WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 63

TAFO, GHANA.

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SIXTY-THIRD QUARTERLY REPORT

JULY - SEPTEMBER, 1961

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in WACRI Technical Bulletins and elsewhere.

SENIOR STAFF

Ag. Director	J.W. Blencowe
Secretary	A.F. Neale (returned from leave 23/7/61)
Accountant	J.N.A. Hyde

TAFO STATION

Division of Entomology	E. Dunn (on leave prior to conclusion of secondment 27/9/61) J.A. Dunn (joined 1/8/61) K.B. Armstrong (on leave prior to resignation 14/9/61) M.R. Smith B.M. Gerard Mrs. P. Gerard (part-time) E.O. Boafo
Division of Pathology	J.W. Blencowe (Ag. Director) A.L. Wharton P.D. Turner A.A.F. Brunt A. Attafuah (on scholarship in U.K.) N.K. Lovi J.K. Bonney
Division of Botany	D.R. Glendinning R.G. Lockard E.J.A. Asomaning Miss V.A. Martinson (joined 1/9/61, on post-graduate training in U.K. from 15/9/61). E.A.T. Asante
Division of Chemistry	R.H. Kenten J.C. Burridge (on leave) R.W. Smith (returned from leave 19/8/61) D.K. Acquaye G.S. Akrofi
Division of Agronomy	T.H.R. Hall
Statistician	C. de Jonge (returned from leave 24/7/61)
Plantation Manager	H.W.S. Allison (on leave 27/7/61)
Asst. Plantation Manager	E.O. Quao
Maintenance & Electronics Engineer	G.O. Hayward
Asst. Maintenance Engineer	G.O. Amponsah
Works Superintendent	E.K. Berko (returned from leave 22/7/61)
Guide-Demonstrator	F.E. Decker
Medical Officer	P.K.K. Knudsen (returned from leave 17/8/61)

IBADAN STATION

Deputy Director	T.W. Tinsley
Secretary	H.Ll. Pugh (returned from leave 13/9/61)
Entomologists	R.G. Donald (on leave 15/8/61) P.F. Entwistle (returned from leave 1/9/61)
Statistician/Agronomist	G.H. Freeman
Soil Chemist	M. Wessel
Plant Physiologist	N.I.C. Nwachuku (at University of Hawaii - 11/9/61
Plant Pathologists	E.C. Hislop (returned from leave 19/7/61) J.F. Longworth (returned from leave 2/8/61) Mrs. P.C. Wessel-Riemens (part-time)
Plant Breeder	H. Toxopeus (joined staff 1/7/61)
Plantation Officer	W. Rides

ADMINISTRATION

STAFF MATTERS

Dr. J.W. Blencowe attended an F.A.O. Conference in Rome in July, on problems of Plant exploration, introduction and quarantine. Dr. Blencowe and Dr. T.W. Tinsley attended the London Cocoa Conference in September, this Conference was also attended by other members of the staff who were on leave in U.K.

Dr. J.A. Dunn, has been seconded to the Institute from the National Vegetable Research Station, Wellesbourne, Warwick and joined the staff at Tafo on 1st August. He took over, as Head of Entomology Division, from Mr. E. Dunn when the latter left at the end of September.

Mr. N.I.C. Nwachuku returned to Ibadan on 19th August at the end of a period of attachment to Tafo Station. He subsequently left for the University of Hawaii where, on 25th September, 1961, he started a two-year post-graduate course. Messrs. E.K. Berko, A.F. Neale and C. de Jonge returned from leave in July, and Dr. P.K.K. Knudsen and Mr. R.W. Smith in August.

Miss V.A. Martinson joined the staff as a Plant Breeder on 1st September, and proceeded to the United Kingdom on post-graduate training on 15th September.

Mr. H.W.S. Allison went on leave in July. Messrs. K.B. Armstrong and E. Dunn left in September both on leave prior to conclusion of contract.

In Ibadan Station, Mr. E.C. Hislop returned from leave on 19th July, Mr. J.F. Longworth on 2nd August, Mr. P.F. Entwistle on 1st September and Mr. H.L. Pugh on 13th September, 1961.

Mr. R.G. Donald went on leave on 15th August. Mrs. P.C. Wessel-Riemens was engaged on a part-time basis as a Plant Pathologist on 1st May, Mr. H. Toxopeus, Plant Breeder, joined the staff on 1st July, 1961.

VISITORS

The Tafo and Ibadan Stations were honoured by visits of the Duke of Devonshire, Under Secretary of State for Commonwealth Relations. Other distinguished visitors to Tafo included Herr Schlolz, Deputy Prime Minister of the German Democratic Republic in September, Mr. K.D. Taylor, Rodent Liaison Officer of the U.K. Ministry of Agriculture, Mr. B.R. Law of Mars Ltd., Mr. Rao of Indian Ministry of Agriculture, Mr. Walker of the Fiji Department of Agriculture, and three Japanese Chocolate Manafacturers.

Other visitors to Ibadan Station were Mr. E.N.G. Smith of the Tropical Products Institute, and Dr. W. Railston of the Department of Technical Co-operation, London.

APPARATUS

The Spinco ultra-centrifuges have now been installed at Tafo and Ibadan and are proving most valuable additions to our facilities.

PLANTATION MANAGEMENT DIVISION

Activities of this Division comprised mainly routine maintenance and harvesting of non experimental plots in both the Square Mile and the Old Station Farm. Routine inspection for swollen shoot detection continued and outbreaks were dealt with according to the present policy.

Details of yields from the Square Mile and Old Station Farms are given in Tables 1 and 2.

Period	Young Planted Cocoa				Mature	Total Pods 1961	Total Pods 1960
	Amelo-nado	Amazon	Trini-tario	Hybrids			
July	15,948	339	70	556	27,364	44,277	63,195
Aug.	6,240	121	60	42	7,437	13,900	107,354
Sept.	20,339	234	103	122	34,497	55,295	111,100
Total	42,527	694	233	720	69,298	113,472	281,649

Table 1. Gross yields from the Square Mile

Period	Amelo-nado	Amazon Mixed	Mature cocoa	Total Pods 1961	Total Pods 1960
July	4,257	4,182	11,968	20,407	50,990
August	874	1,797	3,065	5,736	74,204
September	4,832	3,325	19,808	27,965	91,031
Total	9,963	9,304	34,841	54,108	216,225

Table 2. Gross yields from Old Station.

SWOLLEN SHOOT CONTROL

Details of trees destroyed due to swollen shoot control measures and undiagnosed causes are given in Tables 3and 4.

Month	Cocoa destroyed due to			Total	Total seed-lings removed
	Swollen shoot	Contact	Undiagnosed		
July	43	32	1	76	25
August	19	12	-	31	22
Sept.	14	9	2	25	23
Total	76	53	3	132	70

Table 3. No. of trees removed on Old Station Farm.

Month	Cocoa destroyed due to			Total	Total seed-lings removed
	Swollen Shoot	Contact	Undiagnosed		
July	55	28	-	83	-
August	48	23	-	71	-
Sept.	39	28	-	67	-
Total	142	79	-	221	-
Grand Total	218	132	3	353	70

Table 4. No. of trees removed due to swollen shoot from Square Mile.

EXTENSION WORK

The clearing of 80 acres for planting during the next two years was begun in the latter half of August.

AGRONOMY DIVISION

OLD STATION FARM

Yield

The yield in pods for the thirty-two quarter-acre plots is given in Table 5.

Plots	Total Pods	Diseased	Percentage	Healthy Pods
Tree recorded (5)	1,494	163	10.9	1,331
Plot recorded (27)	6,407	1,098	17.1	5,309
Total (32)	7,901	1,261	16.0	6,640

Table 5. Pods from 32-$\frac{1}{4}$acre plots - Station Farm.

SQUARE MILE

Maintenance of Mature Cocoa

The yields from mature cocoa are given in Table 6. Routine weeding and removal of dead branches was carried out

No.	Plot	Experiment	Sept. (1961) Quarter	Sept. (1960) Quarter
1	B2	U.A. Spacing and Pruning	3,304	19,543
2	B2(a)	U.A. Spacing Extension	888	5,566
3	B1	U.A. Multiplication	4,982	28,159
4	J1	Amelonado Spacing Trial	15,404	49,490
5	G5	Factorial Fertilizer Trial	4,414	10,400
6	H1 & L2	2nd Establishment Trial	17,435	25,000
7	G1	Uniformity Trial	40,900	71,752
8	P2	Amelonado Pruning Trial	3,109	4,702
9	G4	Amelonado Source Trial	3,294	4,891
10	K1	Shade and Manurial Trial	27,867	56,937
11	A4	Comparison of Virus Strains	163	601
12	A6	Cover Crop and Fertilizer	874	5,806
13	H2	Virus on Amazon Cocoa	570	1,624
14	H3	Virus on Amelonado Cocoa	343	1,054
15	P1	Early Bearing Experiment	6,882	5,329
		TOTAL	130,429	290,854

Table 6. Yields from Experimental Plots - Square Mile

during the quarter. A number of the large dead tree trunks in the Amazon Spacing Trial fell in September, doing considerable damage. A small out-break of white thread blight has been observed in the Amazon Spacing and Pruning Trial. A second fertilizer dressing of Urea was applied on H2 and H3 (Effect of Virus on Amazon and Amelonado cocoa experiments) in September.

Maintenance of Young Cocoa

Routine weeding and manipulation of the nurse shade was continuous during the quarter. At the Black Pod variety susceptibility trial at Mpraeso, instead of cutting back excess tree cassava canopy, the shading was reduced by slashing side growth and that part of the canopy over the cocoa rows with a stick.

New Plantings

Five acres of the second block of the Hybrid Shade and Manurial Trial were planted at the beginning of June. The heavy rain in June caused waterlogged patches to remain longer than was anticipated. Planting in these areas has been a complete failure despite the digging of extensive drains.

CLONAL NURSERY

Twenty rooted cuttings of each of the following clones were planted in an extension to the Clonal Nursery, T63/967, T16/613, T86/982, T12/151, T12/150, T12/113, T79/467, T60/1776, T60/1775, T60/1774, T60/1773, T60/1052, T60/1051, T60/1049, T60/976, Lafi No.7, T60/963, T60/888, T60/885, A12, A73, Na34/807, Na33/564, T63/971, T63/882, T76/1224, T72/1767, T85/799, T60/964, T60/973 and T60/975, while 19, T60/974, 11, Na31/566 and 13 Clone 12B were also planted.

Weekly and monthly counts of cuttings available from the older clones were made during the quarter. The cuttings as they became available were used to assess the rooting potential of the individual clones.

PROPAGATION

Varving quantities of cuttings of different clones were rooted for use in the Institute. A further attempt to root Bombax brevicuspe (Sprague), using four different rooting media and two different hormone concentrations, failed.

Plot	Experiment	Pods	
		July-Sept. 1961	April-June 1961
D7	Amazon Tree Forming	612	1,416
A3	Clonal Collection	2,896	1,439
E1(a)	Shade Efficiency Trial	127	127
E1	Variety Trial - Virus Resistance	37	159
K2 & O1	Amazon Shade and Manurial Trial	1,496	1,676
TOTAL		5,168	4,817

Table 7. Yields in Pods of Young Cocoa

ORNAMENTAL NURSERY

One hundred sweet orange stock were budded with Marsh seedless grapefruit and Anomabu sweet orange. Fifty sour orange stock were budded with Eureka rough lemon varieties from Bunso.

An extension to the ornamental nursery has been planted with Terminalia seedlings for the 1962 planting areas. Over 50,000 seeds have also been sown.

DISTRIBUTION OF PLANTING MATERIAL

Amazon Pods	
W.R. Nigeria Department of Agriculture	7,893
W.A.C.R.I. Employees	8,040
	15,933
Amelonado Pods	
W.A.C.R.I. Employees	1,500

METEOROLOGY

	1961		Past 23-year Means	
Month	Rainfall (ins.)	Wet days	Rainfall (ins.)	Wet days
July	6.78	20	5.58	13.8
August	0.58	6	2.51	12.5
September	5.85	11	6.09	17.1
TOTAL	13.21	37	14.18	43.4

Table 8. Rainfall

PATHOLOGY DIVISION

VIRUS RESEARCH

MECHANICAL TRANSMISSIONS OF COCOA SWOLLEN SHOOT VIRUS (CSSV)

In addition to the susceptible species from which infective extracts have been prepared previously (Rep. W. Afr. Cocoa Res. Inst., 1960-61) CSSV has now been transmitted to cocoa from Pterygota macrocarpa K. Schum. and Cola lateritia K. Schum.

Work continued on the factors which could affect the infectivity of unconcentrated inocula from cocoa, Bombax brevicuspe Sprague and Adansonia digitata L. but no increase in infectivity over that previously reported has been achieved.

It is thought that the low infectivity of extracts from plant tissue infected with CSSV is due to low virus concentration in the tissue. For, it has been shown that the virus is reasonably stable in vitro (Quarterly Report 62) and

although infective extracts have been made from a number of susceptible species and by several different extraction procedures the infectivity has always been low.

Attempts are now being made to concentrate CSSV from a number of different host plants using the recently installed ultracentrifuge.

BLACK POD DISEASE

FUNGICIDE CONTROL TRIAL

Mr. Freeman advised on the complete analysis of the first (1960) season's results. Unlike the method used to give preliminary results in Quarterly Report No. 61, data for all the unsprayed plots was pooled and comparisons of the two Perenox treatments (A) and (B) against Control (C) are given in Table 9. Data for loss of crop (cf. Quarterly Report 61) are included, as well as figures for incidence of disease. The method of analysis

Treatment	Total pods per acre	Percentage "black-pod"	
		Incidence	Loss
A	9,909	19.7 **	13.7 *
B	11,036*	16.7 ***	10.6 ***
C	9,559	27.8	18.8

Significant differences compared with control *, **, *** represent P = 0.05, 0.01 and 0.001 respectively.

Table 9. Perenox spraying trial - 1960 data.

shows no significant difference between the two Perenox treatments for either incidence of disease or absolute loss of crop, although the effect of both in controlling 'black pod' is significant when compared with the data for unsprayed plots.

The table also shows the mean numbers of total pods per acre harvested during the 1960/61 crop season. The difference in total pods between the two Perenox treatments is not significant but the positive difference between treatment B and control is ($P = 0.05$). It represents a substantial increase in yield of 15.5 per cent over the control. Even though the treatment data has been corrected for pre-treatment differences in yield over the 3 seasons 1957 to 1959 the effect must be accepted with reserve until data from a second year of Perenox treatments is collected.

MECHANISMS OF RESISTANCE AND TOLERANCE TO PHYTOPHTHORA PALMIVORA

Work has continued on laboratory tests to distinguish between selections showing low and high field susceptibilities to Phytophthora pod rot. Growth of the fungus on tissue extracts has been measured by the rate of colony development on agar plates and by the dry weight of mycelium produced in liquid cultures. For extracts of cherelles and external endocarp tissues 5.0 gm. of each tissue were macerated for 30 seconds in 200 ml. deionised water and filtered through cotton wool; 5 per cent. extracts were prepared of internal endocarp tissues. For growth rate measurements 3 per cent agar was added and 15 ml. of autoclaved medium poured into each Petri plate. 20 ml. aliquots in 100 ml. conical flasks were used for mycelial dry weight assessments. In other dry weight tests, Czapek Dox salts containing thiamin and sucrose supplements were added. Standard inoculation of plates and flasks was made using cork borer discs from colonies of the fungus on plates containing 15 ml. of potato dextrose agar. Replicates of three aliquots of each tissue extract from each of 5 cherelles, large unripe, and mature pods were measured for colony diameter after 3 days and for dry weight after 4 days. The mycelium was filtered from liquid cultures onto previously weighed filter papers, dried at 90°C. for 4 hours, and weighed.

No significant differences were observed between selections in growth rates on tissue-extract agar plates, for which the results are summarized in Table 10. The rate was slightly higher on tissue extracts of large immature pods than on those from pods of other developmental stages. A similar situation was found with dry weight measurements, summarized in Table 11, although some indication was found of differences in growth on extracts of internal endocarp tissues of large unripe pods, particularly when the media were supplemented.

GALL DISEASE

Studies on the etiology of the gall disease of cocoa in Ghana, caused by a strain of Calonectria rigidiuscula (Berk. & Br.) Sacc. have now been prepared for publication in detail.

Little further work on this disease is planned although some studies are being made on how the gall inducing isolates of the species differ from those which cause dieback but not galls.

Disease Incidence	Selection	Cherelle	Large unripe		Mature	
			E. E.	I. E.	E. E.	I. E.
High	A62	5.3 ± 0.0	5.6 ± 0.0	5.2 ± 0.0	5.0 ± 0.0	4.8 ± 0.0
	A12	5.6 ± 0.1	5.6 ± 1.2	5.3 ± 0.4	NT	NT
	A56	5.2 ± 0.0	5.7 ± 0.0	6.0 ± 0.0	4.8 ± 0.0	5.3 ± 0.0
	R15	5.8 ± 0.0	6.0 ± 0.0	6.3 ± 0.0	5.4 ± 0.0	5.6 ± 0.0
	TF2	6.0 ± 0.0	6.1 ± 0.0	6.3 ± 0.0	4.8 ± 0.0	4.8 ± 0.0
		Mean 5.6	5.8	5.8	5.0	5.1
Medium	P30	6.1 ± 0.0	6.2 ± 0.0	6.4 ± 0.0	6.1 ± 0.0	5.8 ± 0.0
	E1	5.6 ± 0.0	5.9 ± 0.0	6.3 ± 0.0	NT	NT
	ICS1	5.9 ± 0.0	5.9 ± 0.0	6.2 ± 0.0	NT	NT
	02	5.7 ± 0.0	6.2 ± 0.0	6.1 ± 0.0	5.9 ± 0.0	6.1 ± 0.0
	B1	5.8 ± 0.0	6.0 ± 0.0	6.1 ± 0.0	5.6 ± 0.3	5.3 ± 0.4
		Mean 5.8	6.0	6.2	5.9	5.7
Low	D70	5.6 + 0.5	NT	NT	6.1 ± 0.0	6.2 ± 0.0
	Y44	5.5 ± 0.0	5.2 ± 0.0	5.9 ± 0.0	5.3 ± 0.0	5.1 ± 0.3
	U6	5.3 ± 0.0	5.7 ± 0.0	5.8 ± 0.0	5.1 ± 0.0	5.6 ± 0.0
	S27	5.5 ± 0.0	6.2 ± 0.0	5.7 ± 0.0	5.5 ± 0.3	4.9 ± 0.0
	ACu85	5.4 ± 0.0	5.9 ± 0.0	5.7 ± 0.0	5.2 ± 0.0	5.4 ± 0.0
		Mean 5.5	5.8	5.6	5.4	5.4
	Unselected Amelonado	5.8 ± 0.1	5.9 ± 0.0	6.2 ± 0.1	6.4 ± 0.0	6.2 ± 0.0

Table 10. Mean colony diameter (cm.) of P. palmivora on 3 per cent tissue extract agar after 3 days. (EE, IE external-, internal-endocarp tissue. NT, not tested).

Disease Incidence	Selection	Cherelle A	Cherelle B	Large green EE (A)	Large green EE (B)	Large green IE (A)	Large green IE (B)	Mature EE (A)	Mature IE(A)
High	A62	3.2±0.3	12.7±2.3	4.7±0.3	13.2 ± 0.5	8.0 ± 1.0	47.7 ± 10.1	3.5 ± 0.5	9.5 ± 0.5
	A12	4.5±0.7	11.8±1.2	3.6±0.7	17.5 ± 4.1	12.3 ± 0.9	44.0 ± 12.5	NT	NT
	A56	4.1±0.4	10.8±3.3	3.1±0.4	21.0 ± 1.6	12.2 ± 0.8	52.2 ± 5.1	5.0 ± 0.7	8.8 ± 1.5
	R15	4.3±0.6	22.5±4.3	3.9±0.3	22.7 ± 2.2	10.7 ± 0.6	53.1 ± 8.5	2.3 ± 0.0	3.1 ± 0.5
	TF2	7.2±0.8	10.2±4.3	4.4±0.7	9.3 ± 0.5	11.5 ± 1.7	37.4 ± 8.7	4.8 ± 0.4	7.7 ± 1.4
	Mean	4.7	13.6	3.9	16.7	10.9	46.9	3.9	7.3
Medium	P30	7.3±0.6	12.6±2.7	3.8±0.6	2.9 ± 0.0	11.4 ± 1.6	12.9 ± 3.2	3.6 ± 0.6	6.6 ± 1.5
	E1	3.9±0.0	16.4±4.9	4.3±0.4	8.1 ± 1.7	11.1 ± 1.2	39.9 ± 3.7	NT	NT
	ICS1	5.1±0.4	9.1±3.5	3.4±0.4	7.3 ± 1.5	9.9 ± 0.6	53.7 ± 17.2	NT	NT
	02	4.4±0.5	14.9±5.0	2.6±0.6	15.2 ± 3.1	11.1 ± 0.9	46.2 ± 11.4	4.3 ± 0.7	9.0 ± 1.4
	B1	4.6±0.0	13.9±5.8	2.8±0.0	6.0 ± 1.6	9.5 ± 0.9	17.8 ± 3.8	4.0 ± 0.5	7.8 ± 1.7
	Mean	5.1	13.4	3.4	7.9	10.6	34.1	4.0	7.8
Low	D70	4.7±0.7	20.0±5.1	5.4±0.4	4.4 ± 0.6	10.4 ± 0.5	5.5 ± 1.3	2.9 ± 0.4	5.4 ± 0.8
	Y44	4.5±0.9	27.3±7.2	3.6±0.4	7.7 ± 1.1	9.7 ± 1.4	30.8 ± 3.9	2.6 ± 0.5	6.7 ± 1.3
	U6	4.4±0.6	21.8±4.8	4.1±0.0	6.0 ± 1.3	9.0 ± 0.9	21.7 ± 3.1	3.5 ± 0.0	5.8 ± 0.8
	S27	3.9±0.3	27.9±8.6	1.8±0.0	10.1 ± 3.1	4.2 ± 0.7	44.6 ± 13.3	3.5 ± 0.7	4.2 ± 0.5
	ACU85	3.8±0.6	24.8±3.6	3.5±0.0	22.1 ± 3.4	9.7 ± 0.6	43.2 + 8.5	2.6 ± 0.5	5.7 ± 0.9
	Mean	4.3	24.4	3.7	10.1	8.6	29.2	3.0	5.6
	Unselected Amelonado	5.8±0.7	16.1±4.7	3.9±0.4	13.5 ± 2.0	11.4 ± 0.4	34.8 ± 6.3	3.1 ± 0.6	5.6 ± 0.8

Table 11. Dry weight (mgm.) of P. palmivora in tissue extract cultures after 4 days. A = Water extract B = supplemented medium, EE, IE = external-, internal-endocarp tissue. NT = not tested.

Table 12 gives the results from an experiment to determine if gall isolates would induce dieback lesions comparable with those produced by dieback isolates.

Inoculum		Source	Lesion length (mm.)
Nutrient agar (control)			No growth
P. palmivora		Diseased pod	57.0
C. rigidiuscula	A101	Gall	62.4
	B151	Gall	51.4
	B75	Gall	45.8
	614	Dieback tissue	41.1
	613	Dieback tissue	31.0
	B282	Dieback tissue	26.7
	A107	Gall	22.7
	617	Dieback tissue	17.7
	616	Dieback tissue	14.3
	A106	Gall	12.3
	615	Dieback tissue	12.0

Lesion length: Mean of 10. Includes diameter (5 mm.) of inoculum disc.

S.E. = ± 5.11. L.S.D. (1%) 18.9, (0.1%) 24.4 with 108 d.f.

Table 12. Growth rate of isolates in stems of one-year-old seedlings 8 weeks after inoculation.

The stems of one-year-old Amelonado seedlings were wound-inoculated with a standard amount of mycelium from each of the following 13 nutrient agar cultures: gall isolates of *C. rigidiuscula* (5), dieback isolates of *C. rigidiuscula* (6), *Phytophthora palmivora* (1), nutrient agar control (1). Each culture was inoculated into 20 seedlings and after 2 months half the seedlings were harvested, the stems split longitudinally through the sites of inoculation and the length of the lesions measured.

The results given in Table 12 confirmed that gall isolates induce lesions equivalent in size to those caused by dieback isolates. Both types of isolate differed widely in their pathogenicity. One gall isolate of *C. rigidiuscula* (A101) was outstanding in causing severe lesions equal in size and appearance to those caused by *P. palmivora*. The remaining seedlings will be harvested and the lesions measured after a further 2 months growth.

ENTOMOLOGY DIVISION

ANT/MEALYBUG STUDIES

The survey of ants and mealybugs under different cultural conditions is continuing. A rapid rise in mealybug populations has occurred in plots K2, E1 and H4 during the quarter, while in N9 the numbers of mealybugs have decreased considerably.

THE EFFECT OF BHC ON ANT POPULATIONS

Two plots at Tinkong were sprayed with gamma BHC at the rate of 4 oz. per acre on 8th August and at 2 oz. per acre on 26th September. Pre-treatment data showed that the plots contained different proportions of Crematergasterine and Camponotine ants and that Pheidoline ants were absent from Plot 1. It is hoped that, by applying a routine type gammalin spray, as for capsid control, to these plots, any ant susceptibility to BHC that might exist can be shown to be specific or non-specific. Fortnightly surveys are being made on the plots and the number of ant-infested cocoa trees are noted as well as the type (i.e. the size) of the ant infestation on each of these trees.

POLLINATION STUDIES

Collection of pre-treatment data, as described in Quarterly Report No. 62, has continued.

Different habitats have been sampled to find larvae of Forcipomyia spp. (Ceratopogonidae: Diptera) using Berlese - type extraction funnels. The specific identification of larvae is easier to determine than that of the adults, but it will be necessary to obtain adults in order to relate the two stages, and to find which are the main pollinating species.

MINOR PESTS

MARMARA STUDIES

A detailed survey in H2/3 and some selected plots designed to emphasise any differences between Marmara populations on cocoa trees up to 6 feet above ground level gave the results shown in Table 13.

Block	Date	No. of trees examined	No. of pupae on trunks	No. of pupae on pods	No. of pupae on leaves
H2/3	12-7-61	134	69 (range 0-11 per tree)	22 (range 0-4 per tree)	10 (range 0-9 per tree)
D5	13-7-61	137	0	0	0
A1	14-7-61	136	0	1	0

Table 13. Number and position of pupae of the 'pod-husk miner' on cocoa trees in 3 plots at Tafo (July, 1961).

H2/3 had been sprayed with dieldrin, and from a general survey seemed to be the focus of a high Marmara population. D5 was selected because it is adjacent to H2/3 and had a high population of Marmara larvae although it had not been sprayed with dieldrin. At the time of recording A1 had not been sprayed for several years, the larval population was low.

A routine weekly survey was started to compare the populations in H2/3 and A1 (parts of which will be sprayed with the standard application of BHC in future).

Adults bred from the pupae found in H2/3 have been separated into three species. One of these species was represented by a single specimen bred from a pupa formed on a cocoa leaf. The most numerous species obtained had not previously been bred from cocoa; the pupae came from trunks, pods and leaves. A taxonomic study of these species has been started and a list of the specific characters will be included in a later Quarterly Report.

In order to find the distribution of the species involved adults are now being bred from pupae obtained from pods and trunks, taken from every part of W.A.C.P.I. A collection of adult specimens of Lithocolletidae (= Gracilariidae) has been made from daily light trap catches. Many adults of a species in this family were obtained from pupae abundant on cocoyam leaves on a plot near Bunso; large numbers of the 'pod-husk miner' were present on this plot during the main crop season of 1960, following applications of dieldrin in November, 1959.

GENERAL ENTOMOLOGICAL STUDIES

Collections of larvae of Auchenorrhyncha (Homoptera) feeding on young pods and chupons have been made in D and H Blocks only. The following list summarises the results:

No. of species	Family	
5	Cicadellidae	Adults bred from larvae fed on young pods and flush tissue in the laboratory.
1	Membracidae	
2	Ricaniidae	
1	Derbidae (?)	
1	Cicadidae	- Adults bred from larvae found crawling up cocoa trunk.
5	? Cicadellidae	Adults not successfully bred from larvae fed on pods and flush tissue in the laboratory.
3	Fulgoroidea	
1	Membracidae	Adults found apparently feeding on young pods and flush tissue.
1	Cicadellidae	
1	Hylicidae	
1	Derbidae	

EELWORM STUDIES

Soil and root samples have been taken from various plots at W.A.C.R.I. to determine which plant parasitic nematodes are present.

Preliminary investigations have started on roots of shade plants and of cocoa growing under them to determine whether any plant parasitic nematodes are common to both.

BOTANY DIVISION

PLANT BREEDING

FIELD EXPERIMENTS AT TAFO

In the comparison of reciprocal crosses between an Amazon parent (Na32) and an Amelonado (S45), (Experiment N13/1 planted in the field in 1959), the cross with the Amazon parent as female is still slightly ahead of its reciprocal, stem diameters in May 1961 being 5.65 cms (Amazon as female) and 5.24 cms (Amelonado as female). Some of this difference is probably because the seeds from the Amazon parent were larger, but a suggestion of a higher growth rate in the progeny from the Amazon parent is now emerging. Increases in stem diameter from January, 1960 to May, 1961 were 3.58 cms and 3.26 cms, (statistical probability under 20%).

In the comparison of crosses of Pa35, Na32 and T63 (= Pa35 x Na32) to Amelonado (Experiment N13/3) it is now abundantly clear that the cross involving Pa35, while of good performance, is inferior to the others (Table 14).

	May 1961	Increase from Jan. 1960 to May, 1961
Pa 35 x Amelonado	4.46 cm.	3.18 cm.
Na 32 x Amelonado	5.26 cm.	3.75 cm.
T63 x Amelonado	5.24 cm.	3.67 cm.
L.S.D. at 1% level	0.541 cm.	0.442 cm.

Table 14. Stem diameters in Experiment N13/3.

The evidence from leaf numbers is similar. Whether this inferiority is due to inherently lower vigour or to greater susceptibility to attack by pests or diseases is not yet clear. However the very good performance of the cross to Na32, equalling the cross to T63 (which is Series II variety 'A'), is very pleasing.

In the comparison of crosses between Amelonado and Amelonado-like varieties from various sources, all crosses have grown better than the ordinary Amelonado inserted into the experiment as controls (Experiment N13/4). The best progeny is from the cross of the Nigeria clone T(N)38 to Asuansi Amelonado S84 (Increase in diameter relative to 'controls' 1.38:1). Second and third best are crosses of Asuansi and Aburi Amelonados to Amelonado from Kpeve (Increases relative to controls 1.26:1 and 1.16:1). It now seems possible that improved Amelonados for use in the breeding programme may be obtained in this experiment.

LEAF RETENTION IN THE DRY SEASON

In the INA Series I trial in Nigeria, planted in 1958, growth was much less in 1960-61 than in 1959-60. The degree of setback in 1960-61 differed between varieties, and those which were least set back were also those which lost a lesser percentage of their leaves over the 1959-60 dry season ($r = 0.92$, $p = 0.01$; for 5 varieties). While this offers a strong suggestion that leaf retention over the dry season is related to tolerance of dry conditions, it has not yet been possible to confirm this effect in other trials.

QUALITY REPORT, BRITISH MANUFACTURERS

The report by the British manufacturers on samples of cocoa sent early in 1960 was received during July, 1961. In general it is highly satisfactory in that all the varieties of immediate importance were classified as of West African type, though often with minor reservations, e.g. with comments that a particular sample was rather fruity, or weak in chocolate flavour or containing rather small beans etc.

The two Amelonado samples included in the series were also recorded as weak in flavour, and obtained relatively poor assessments.

Comparison of the British reports to the American reports (discussed in Quarterly Report 62) indicates that the American firm that was substantially out of agreement with the other four in details of preference among the samples is that which is most in agreement with the British firms.

In general it may be said that there is nothing in the reports received from the manufacturers to give rise to concern at the direction in which the breeding programme is proceeding.

PLANT PHYSIOLOGY

MINERAL NUTRITION

The initiation of Experiment 1 (to test on plants in sand-culture the interaction between macronutrient deficiencies and swollen shoot virus) were reported in Quarterly Report No.62, together with most of the results of the first harvest. During this quarter the chemical analyses have been completed and another harvest taken (125 days from seeding).

The chemical analyses of the first harvest followed the pattern expected, with low levels of the macronutrient in those plants receiving deficient amounts of the corresponding nutrient. There was no marked difference in nutrient level between virus-infected and healthy plants.

At the second harvest the dry weight of virus-infected plants was 50.8% of healthy plants as compared to 66.4% at the first harvest. No records showed a significant difference between nutrient treatments. For this reason the nutrient treatments were made more severe (elements reduced to zero) following this harvest.

Experiment 2 was started on July 21st. This experiment in sand-culture is similar to Experiment 1 except that it is designed to test the interaction of micronutrient deficiencies with swollen shoot virus. As in Experiment 1 there are several deficiency treatments (Cu, Zn, Fe, Mn, B, and Mo) plus two excess treatments (Cu and Fe). No harvests have as yet been taken but deficiency symptoms have appeared on the leaves of plants in every deficient treatment noted above. In fact growth stopped completely in the minus Fe, Zn and B treatments and a small amount of these nutrients was added to the respective treatments in order to save the plants and initiate growth.

Experiment 3 was started on August 10th. This experiment is a comparison of growth of plants in sand-culture infected with the following virus isolates.

(1) Dawa
(2) New Juaben
(3) Bosomuosu
(4) Bisa
(5) Kpeve.

All plants receive a complete nutrient supply. There are four plants per pot one of which will be harvested every three months interval.

CHEMISTRY DIVISION

SOIL FERTILITY

FIELD EXPERIMENTS

Amelonado Shade and Fertiliser Trial

Irrigation during the drought referred to in the previous Quarterly Report (No.62), has produced a flowering peak in July, which was absent on the non-irrigated plots. This should be reflected by the prolongation of the Main crop on the irrigated areas after the non-irrigated harvest peak has passed. Table 15 shows the yield from March to September, 1961, compared with that of the same period in 1960.

Treatment	Non-irrigated (0.9 acres per treatment)			Irrigated (0.45 acres per treatment)		
	Total pods 1960 (A)	1961 (B)	$\frac{B}{A}$ x 100	Total pods 1960 (C)	1961 (D)	$\frac{B}{A}$ x 100
Shade No fertiliser	4,800	3,600	74.5	2,100	1,500	71.3
Shade with Fertiliser	7,700	6,200	80.4	2,700	2,100	78.6
No shade No fertiliser	12,200	4,100	33.6	5,900	3,600	61.6
No shade with Fertiliser	19,300	8,200	42.5	8,100	6,300	78.2

Table 15. Yields from the Amelonado Shade and Fertiliser Experiment, March - September, 1960 and 1961.

The shaded plots have shown a particularly low yield during the last two years. This is a reflection of the increased intensity of the shade caused by growth of the Glyricidia shade trees. It has been decided to reduce this shade by selective poisoning during the dry season in order to obtain more realistic shade conditions before the next cocoa season.

Amazon Shade and Manurial Trial

This trial is still under calibration by harvest records, the fertiliser treatments not yet having been applied, and the whole area growing under "uniform" shade of Terminalia ivorensis. Stem diameters and height have been recorded throughout the area.

The Effect of Fertiliser at the Time of Planting on Amazon, Amelonado, and Hybrid Cocoa (D11)

The establishment of this new experiment has been satisfactory with the exception of one replication, situated in the lowest portion of the area which has been subject to water-logging. This replication has therefore been abandoned, and a further replication was planted during the quarter at the opposite end of the area. The adjacent cocoa (D12), to be used for work on fertiliser responses during the early years of the cocoa plantation, has established satisfactorily. Application of fertiliser will commence in April, 1962.

Joint WACRI - Cocoa Division Trials

All these experiments are progressing satisfactorily.

The factorial trials at Apedwa (Plot 1080) and Bunso (Plot 1006) consist of three and two Amazon varieties respectively. These varieties are not equally represented in the fertiliser treatments, but work is now in progress to summarise the results on a varietal basis and to determine whether differential varietal fertiliser responses can reliably be detected.

Fertiliser Application

The application of nitrogenous fertilisers on the fertiliser experiments at WACRI and the Joint WACRI Cocoa Division experiments in the Eastern Region was completed during the quarter. Joint experiments in the other regions no longer receive an application in September.

Soil exposure experiment

The seedlings which were planted at the former soil exposure site have maintained good growth. Initial height measurements have been taken and fertiliser applied.

Pot Experiment

The pot experiments reported in Quarterly Report 61 in which rock- and triple- super-phosphate and urea and sulphate of ammonia are being compared have continued. The seedlings have continued making good growth and they will be harvested in the middle of November, 1961.

LABORATORY STUDIES

The soil phosphorus studies are continuing and it is hoped to investigate systematically such factors as temperature, moisture, pH and other nutrients which are related to the mineralisation of organic phosphorus in the laboratory and under field conditions.

The laboratory investigations on the various soil series at WACRI have continued.

Estimation of Sulphur in Soil

Recent work in Australia has shown that sulphur deficiency can restrict both the response to super-phosphate and the build-up of organic matter in soils. Work has therefore been commenced to assess the sulphur status of some Ghana cocoa soils in order to examine how phosphorus response is affected by it. Trials of various turbidimetric procedures have not yielded reproducible results. A colorimetric method by Lambert et. al. (Analyt. Chem. 27, 800, 1955) using thorium borate-amaranth-dye complex is being modified for routine use. Since this work was begun Magar and Pollard (J. Soc. Chem. Ind., Lond., 16, 1961) have published a similar colorimetric method using barium chloranilate which will serve as a basis to estimate the efficiency of the method.

Plant Analysis

The Ca, Mg, K, P and N content of 216 samples of plant material was estimated for the Plant Physiology Section.

COCOA PREPARATION

Because of the small mid-crop the mechanical dryer was only used to dry two batches. Both lots of dried cocoa were of good quality with a strong shell and few broken beans.

STATISTICS

ESTIMATION OF PARENT PARAMETERS FROM A TRUNCATED NORMAL DISTRIBUTION

Amelonado cocoa usually starts to bear fruit some seven years after planting, and during the first years of bearing the distribution of numbers of pods per individual tree is decidedly skew. In the third season and later, distribution approaches normality, especially when plots of 16 or more trees are used, (Cunningham & Burridge, J. hort. Sci., 34, 229-237. 1959). It is important for both plant breeding and agronomic experimentation to use these early yield records and speed up the research programme. Because of the skew distribution there is a greater tendency to under-estimate the variance than with older cocoa;

thus the F test under-estimates the transgression probability and suggests a spurious significance for treatment effects if applied to older cocoa. It is customary at this Institute to relate the numbers of pods harvested to a weight of dry cocoa estimated by a conversion factor (e.g. 12 Amelonado pods give, more or less, 1 lb. dry cocoa). Because a sample estimated by weight is not by nature a discrete quantity, it cannot be considered as a sample drawn from the binomial, Poisson or negative binomial distributions. However, it is not possible to use a transformation to convert such a distribution to normality, and it is in any case often difficult to draw practical agricultural conclusions from transformed data. Furthermore Sukhatme's findings (Ann. Eugen., 8, 52-56. 1937) suggest that if such a distribution were regarded as exponential, then a satisfactory analysis would be impossible. If however it is a truncated distribution, it might well prove to be normal and allow a valid F test to be made.

Information on the truncated normal distribution is scarce (but see: Stevens: Ann. appl. Biol., 24, 847. 1937. & Keyfitz, Ann. math. Stats., 9, 66. 1938.) and there is little hope of obtaining good estimates of the parent parameters from entering sample moments in the partial moment equations. A different approach uses regressions; starting with estimated values of the mean and the variance, improved estimates for these can be obtained by iteration, using partial differential quotients. This is very laborious, especially when the initially estimated values prove to have been ill-chosen, and is hardly justifiable because of the limited information available from relatively few trees.

However, the normal density,

$$f(x) = \frac{\exp\left\{-\frac{(x - M)^2}{2S}\right\}}{\sqrt{2\pi S}}$$

where M is the mean and S the variance, rather suggests a logarithmic approach. If N_i is the number of trees producing n_i pods then

$$N_i = Af(n_i)$$

or, in natural logarithms (ln):

$$\ln N_i = \left(\ln A - \frac{\ln 2\pi S}{2} - \frac{M^2}{2S}\right) + \frac{Mn_i}{S} - \frac{n_i^2}{2S}$$

where $\ln N_i = 2.3025851 \log N_i$. Quadratic regression of $2 \ln N_i$ on n_i directly provides an estimate of $1/S$, the factor needed for a valid F test. Three degrees of freedom are singled

out, as in the iterative method, to correspond with S, M and A; for three frequencies (N_i) only, the method provides perfect fit. The residual degrees of freedom, not ascribable to parameters, correspond with differences between actual and computed values, (which in regression analysis are generally considered as normally distributed), and so give rise to a variance estimate with which to test whether the regression term of S is significant. It is important to incorporate as many degrees of freedom as possible by inclusion of isolated frequencies with the aid of the formula:

$$\frac{2N_i}{n_{i+1} - n_{i-1}}$$

This harmonic mean between

$$\frac{N_i}{n_i - n_{i-1}} \text{ and } \frac{N_i}{n_{i+1} - n_i}$$

cannot be larger than the arithmetic mean, and provides a correction to balance the "levelling" effect of regression, leading to smaller values of S. For the last observed frequency N_k, the formula

$$\frac{2N_k}{3(n_k - n_{k-1})},$$

applying to a "terminal triangle", is used. By using these formulae, which cover the range observed, a closer regression is found than by covariance analysis of fixed values of n_i. The greater sensitivity of logarithms towards the tail end of the distribution curve helps with the assessment of small transgression probabilities.

The remaining item of theoretical importance is the relationship of the estimate of A with N, the total number of trees studied. This should be largely reflected in N_o, the number of trees with n_o pods (no crop). If these are restricted to the interval of n from $-^1/2$ to $+^1/2$ there is a tendency to over-estimate A which can be avoided by considering n_{-1} as minus infinity (or leaving N_o out). The difference between the residual sums of squares (which has 1 d.f.) can be tested with a variance estimate derived from the smaller sum of squares. If the test shows significance then the difference between A and N is unimportant. However, if it is found to be insignificant, then the method is proved inappropriate. This might mean that, provided that the assumption of truncated normality is "good", the restriction of frequencies to intervals has been too rigid; this could be overcome by averaging of adjoining frequencies. Should, notwithstanding these attempts, there be no improvement, then the basic assumption of normality for describing the shape by logarithmic quadratic regression is at fault. In that case, an

alternative would be a gamma distribution estimated along the same lines; once that had been established, the transgression probabilities could be read from the χ^2 table.

IBADAN STATION

PLANT PATHOLOGY

VIRUS RESEARCH:

VIRUS TOLERANCE

Effect of selected Nigerian virus isolates on different cocoa types

Insectary experiments: Healthy buds of C77 (Nanay-Iquitos), C64(Nanay), C70(Scavina x ?), C40(Nanay-Parinari), C6(Trinitario) and C26(Trinitario) were grafted onto healthy Amelonado seedlings. Groups of seven budlings of each type were graft-infected with virulent isolates of Abaku, Offa-Igbo, Olanla, Ondo and Ikire viruses, and seven budlings of each type were retained as healthy controls. Observations of symptoms of infection are being made and records of defoliation will be taken to estimate the effect of these isolates on the different cocoa types.

Field Trials: An experiment was planted at Gambari in April, 1960, consisting of three replicates of clonal material of seventeen W.A.C.R.I. 'C' clones. There were eighteen cuttings per plot, nine were graft-infected with a virulent isolate of virus from Ikire in December, 1960, and nine were retained as healthy controls. Observations of symptoms of infection confirmed insectary results. Groups of five cuttings in the healthy controls were later graft-infected with virulent isolates of Offa-Igbo, Ilaro, Olanla and Abaku viruses. Symptoms of infected and effects on growth will be compared with those produced by the Ikire isolate.

Inter-relationships of Nigerian virus isolates

An experiment has been begun in the insectary comparing the effect of virulent isolates from widely separated parts of the Area of Mass Infection and elsewhere in Nigeria on W.A.C.R.I. clone C40 (Nanay-Parinari). This clone has previously given the Parinari necrosis reaction when infected with the Ikire isolate, but not with isolates from Offa-Igbo, Abaku or Olanla, and production of necrotic symptoms in this clone by other isolates may indicate relationship with Ikire. If such instances occur they will be later checked by cross-protection tests.

Virus tolerance field trial at Gambari

Five field experiments totalling 6½ acres were planted in July, incorporating material derived from hand-pollinations made during the previous year at Ibadan and Tafo.

The aims of these trials are:-

(1) To investigate the inheritance of the tolerance of W.A.C.R.I. Clone 77 (T85/799).

(2) To compare the vigour and tolerance of hybrids between tolerant Amazons and tolerant Trinitarios with Series II hybrids.

(3) To determine the level of tolerance in T12 (Scavina x ?).

(4) To investigate the inheritance of the Parinari necrotic reaction.

(5) To determine the levels of tolerance, and inheritance of tolerance in selected Nanay, and Nanay-Iquitos Amazons.

The trials were planted on clear-felled land at 4 ft. by 4 ft. spacing, and a complete cover of grass mulch is being applied. Shade of palm-fronds supported on bamboo poles has been erected. The seedlings will be infected with virus in February, 1962.

The inheritance of tolerance and susceptibility in Amazon cocoa

A programme of selfing selected self-incompatible Amazon types was begun in April, using the technique described by Glendinning (Nature Lond., 187, 170, 1960). The first pods harvested from Na32 and T12 have given between one and four putative selfs. These seedlings will be "twinned", one twin will be infected and the other retained for future breeding work. The "axil-spot" character is readily detectable in the non-selfed seedlings arising from such incompatible "selfings", and can also be observed on the beans. On most beans giving rise to "axil-spot" seedlings, there is a distinct red circle at the tip of the radicle. Beans without an obvious red circle on the radicle may form "axil-spot" seedlings, but some form seedlings without this character and these are considered to be the selfed progeny of the Amazon parent.

A study of the reaction of the putative selfed Amazons to infection will be of value in elucidating the inheritance of characteristic symptoms, in particular the Parinari necrotic reaction, may be of practical importance if tolerant segregants arise from selfing susceptible Amazon types.

BLACK POD STUDIES

LABORATORY STUDIES

Attempts have been made to analyse spray residues of the fungicide Captan, N-trichloromethylthio-4-cyclohexene-1:2-dicarboximide, on pods. To date, the colour reaction of Captan with pyridine and tetracthylammonium hydroxide has been very variable and the method is being re-examined.

FIELD STUDIES

Spraying trial.

A spraying trial was started at Gambari in May in which seven treatments and a control are compared. The spacing trial site used last year is again being used but this time a better experimental design is employed. This design uses all of the differently spaced plots in the non-orthoganal 7 x 7 latin square. The control plots are replicated seven times and occurs once on each spacing. The seven fungicide treatments are each replicated six times.

The treatments being compared are: 1% Bordeaux mixture, 1% Carbide Bordeaux mixture, 0.16% copper as copper oxychloride, 0.05 and 0.10% N-trichloromethylthio-4-cyclohexene-1:2-dicarboximide (50% 'Captan') and 0.04 and 0.06% triphenyl tin acetate. The fungicides are all applied at high-volume rates, by the usual methods, at three-weekly intervals. Harvesting and recording precedes each spraying period.

The incidence of black-pod throughout the site has been high since June, but indications are that the overall yield will be considerably lower than last year.

Black-pod resistance

In collaboration with the plant breeder a number of simple experiments have been carried out to find a method of inoculating undamaged pods with Phytophthora palmivora. The simplest technique tried was to brush a sporangial and zoospore suspension on to Amelonado pods in the field and to examine them after four days. During September, when conditions were ideal for black-pod development, this method resulted in 95% infection of unripe pods and 90% infection of cherelles and young pods. It was therefore decided to apply this method to available cocoa varieties which are producing pods as a first step in the search for black-pod resistance. To date all varieties inoculated by this method have been susceptible.

ENTOMOLOGY

SHOT-HOLE BORER STUDIES

Observations on shot-hole borers on coffee

No attacks have been seen during the quarter.

Gambari Shot-hole Borer Experiment III

This experiment is designed to test the effect of attack by shot-hole borer, Xyleborus morstatti Hag., on cocoa seedlings of different sizes and to obtain further data on the relationship between attack and stem thickness. Four different ages of seedlings, from nursery plantings made in November, and December, 1960 and January and February, 1961, were planted in the field in July in a 4 x 4 latin square, each of the sixteen plots containing 100 plants. The whole experiment is shaded with cut palm fronds supported at six feet above ground level by bamboo poles and inter-row weed regeneration is being allowed, both of which conditions have been found to result in a high incidence of attack. To further encourage attack the area has been planted with two sides adjacent to bush and a third to a row of Robusta coffee, on which breeding populations are likely to develop, (see previous Quarterly Progress Reports). Records of incidence of attack were first made in early September when 28 galleries (1.75 per cent of plants attacked), of which 24 occurred in the two groups of smaller plants, were found.

MINOR PESTS OF COCOA

Observations have continued on the incidence of various minor pests on seedlings in the Gambari Shot-hole Borer Experiment I. Numbers of lepidopterous larvae, which reached a peak in May, were low in June and July but increased again in August and September.

The incidence of Ferrisiana virgata (Ckll.) has declined radically from a peak of 40.9 per cent plants infested in April to none in August and September, but during the same period psyllids (Mesohomotoma tessmani (Aulm.)) have increased from 7.9 to 51.4 per cent of plants infested. The incidence of spider mite (Tetranychus sp., probably undescribed) has declined steadily from a peak of 24.6 per cent of plants attacked in December, 1960, to none in July and August and 1.1 in September, 1961. Aphids (Toxoptera aurantii (Bat.)), which have been absent since last December, reappeared in June and by September were present on 2.2 per cent of plants. The numbers of thrips (Selenothrips rubrocinctus Giard.) have been very low since

February, but an increase began in August and by September 1.8 per cent of plants were infested.

The figures given above refer only to shaded plots, the very high proportion of deaths and the relatively leafless state of those plants remaining in the unshaded plots making comparisons difficult. The experiment will be concluded in October this year.

EARIAS STUDIES

In the larval stage Earias biplaga Wlk. (Lepidoptera, Noctuidae), a common pest of cotton, devours the apical buds and the flush leaves of cocoa. It is present on seedlings throughout West Africa and in the Western Region of Nigeria it is a generally held opinion that its activities are one of the limiting factors to satisfactory establishment. A series of field experiments designed to provide information on the ecology of infestation, the effects on attacked plants and to investigate methods of insecticidal control have been designed and laid down. Observations on one of these commenced in September.

Earias observations on Seedling Establishment Trial II

At fortnightly intervals records are being taken of the numbers of Larvae and pupae present and the numbers of apical buds showing fresh attack. In addition estimates of the amount of regenerative growth following on the destruction of the apical bud are being made on some of the plots. Damaged apical buds are collected from the guard row plants and examined in the laboratory so that the extent of damage may be observed and also so that the possibility of bud destruction by species other than Earias may not be overlooked. On half of the total number of plots all lepidopterous larvae other than Earias are being removed fortnightly so that a comparison can be made between the effects of Earias alone and those of all Lepidoptera together.

NEMATOLOGY

This programme is carried out in conjunction with Dr. F.E. Caveness of the Western Region Ministry of Agriculture and Natural Resources (IDS/ICA Specialists Section).

Plant parasitic nematodes found associated with the roots of cocoa trees in Western Nigeria number about 24 genera and species (Table I.). This number will increase as more samples are gathered and the descriptions of new species are published. This may be as high as five species in the genus Scutellonema and three additional in Helicotylenchus.

A fumigation trial was initiated with the objective of determining the phytotoxic reaction to mature cocoa trees and cocoa seedlings by nemagon (1, 2-dibromo-3-chloropropane) at rates of 1/8th gallon to 16 imperial gallons of active material per acre. The fumigant was injected at a depth of 8 inches in the field and the midway point in each pot for seedlings. The ground area (root area) covered surrounding each tree at each rate of application was 100, 50 and 25 per cent. Each treatment was replicated four times.

No cocoa tree or seedling showed any phytotoxic symptom as late as nine weeks after treatment at any dosage.

Soil samples were taken prior to treatment and after treatment at one replicate of each application rate at the 6 and 18-inch depth. The density average picture at the 18-inch depth is quite similar. The population density drops to zero at the 4 IG/acre application rate.

Scientific Name	Common Name
Xiphinema ebriense	Dagger nematode group
Xiphinema nigeriense	Nigerian dagger nematode
Xiphinema attorodorum	
Xiphinema ifacolum	
Xiphinema longicaudatum	
Xiphinema setariae	
Xiphinema sp. (ad)	
Xiphinema sp. (x)	
Helicotylenchus multicinctus	Cobb's spiral nematode
Helicotylenchus nannus	Steiner's spiral nematode
Helicotylenchus spp.	Spiral nematodes
Hemicycliophora oostenbrinki	Oostenbrinki's sheath nematode
Hemicycliophora sp.	Sheath nematode
Hemicriconemoides cocophilus	Loos's sheathoid nematode
Heterodera (?) larvae	Cyst forming nematodes
Hoplolaimus proporicus	Goodey's lance nematode
Meloidogyne incognita	Southern root-knot nematode
Meloidogyne incognita acrita	Cotton root-knot nematode
Criconemoides spp.	Ring nematodes
Paratylenchus curvitatus	Pin nematode
Pratylenchus brachyurus	Godfrey's root-lesion nematode
Scutellonema spp.	Spiral nematodes
Tylenchorhynchus martini (?)	Sugar cane stylet nematode
Trichodorus sp.	Stubby root nematodes.

Table 16: Plant parasitic nematodes found associated with cocoa tree roots in Western Nigeria.

PLANT BREEDING

Much of the cocoa breeding material at Moor Plantation and Gambari Experimental Station was found to be in poor condition and rehabilitation work has started. A preliminary assessment of value of these seedlings to the breeding programme has been made. The selection and breeding work initiated by Mr. O.J. Voelcker some twenty-five years ago is of particular interest and will be followed up.

Small scale pollination studies to determine existing genotypes of axil-spot, white seededness and incompatibility have been started. The floral characters of F1 Amazon material at Gambari have been studied as part of a larger scheme to classify cocoa trees using morphological criteria.

A method for artificially infecting cocoa pods with Phytophthora palmivora for use in the research for resistance was devised in conjunction with the Plant Pathologist.

SOIL CHEMISTRY

FERTILIZER TRIALS

Field experiments: A second fertilizer dressing was given at the end of September at Araromi (Amazon cocoa, planted June, 1961) and at Gambari (Amazon cocoa, planted 1944). At Gambari Experimental Station, a new fertilizer trial was started with Amelonado seedlings planted in August, 1961. The design is a 3^2 factorial: 3 levels of NP and KMg (single, double, and no dressing) in all combinations. There are 5 replicates and 45 trees per plot.

Pot experiments: Pot experiments are being continued on the effects of different fertilizer combinations and on the effect of foliar applications of major elements.

AGRONOMY

NURSERY TRIALS

The first trial, which was planted out in the field in June, as reported in the last Quarterly Report, has continued to make good progress. An unusually long dry spell in August and September showed up the weakness of sowing in the nursery without shade, especially during the height of the dry season. Of a total of 68 plants dead at the end of the quarter 52 were sown in January or February in unshaded conditions. As a contrast, some plants that had been longest in the nursery were

jorquetting, less than a year after germination. Many plants were attacked by Earias biplaga, but a programme of spraying was started, and this reduced the damage.

The second nursery trial was planted out in the field in July. It was not possible to transfer all the plants because of the poor growth in the concrete beds. Those that are being grown on are progressing well.

SHADE OBSERVATION TRIAL

The cocoa appears to be growing best under a tripod of palm fronds, although it is not growing badly with any of the treatments. Of the shade crops, pigeon pea has given an almost complete cover, with tree cassava and plantain also doing quite well. Crotalaria juncea started off well, but a moderately heavy storm blew all the plants down, and this treatment has had to be abandoned.

STATISTICS

An investigation of the regularity of bearing of cocoa trees has begun. First results are promising, but so much data will be needed for a full study of the problem that it will probably be necessary to use electronic computing equipment. Statistical advice has continued, although this is not a time of year when many trials are planned.

GAMBARI EXPERIMENTAL STATION

Buildings and Services

Work has commenced on the new building contract and tenders have been invited for the electrical installation. The water supply awaits the arrival of pumps for which indents have been submitted to the Crown Agents. Work has commenced on the road which will connect the North and West blocks.

Plantings

Approximately 16 acres of Amazon cocoa and three acres of Amelonado seedlings have been planted. A further 5 acres of Amazon will be planted in the near future.

Transport

A Fordson Dexta Tractor (Diesel) has been purchased.

EGA.